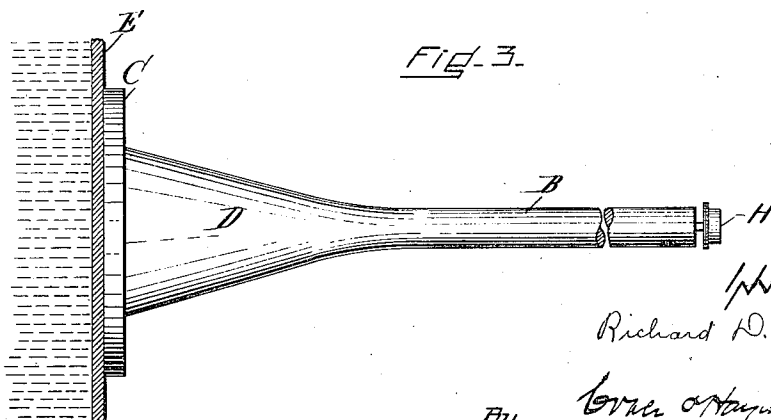
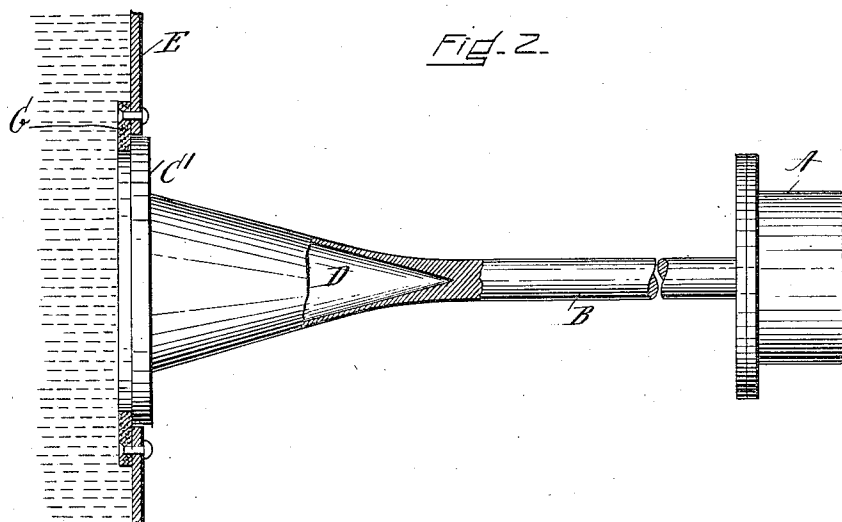
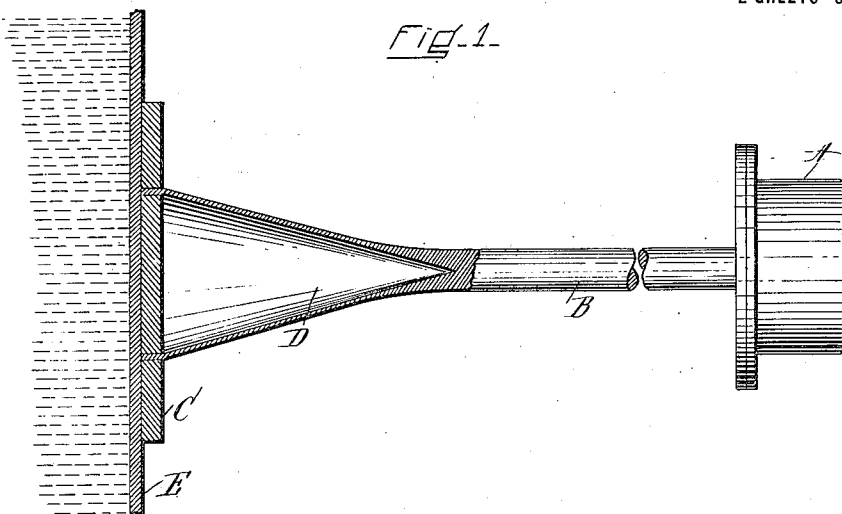


R. D. FAY.
SUBMARINE SIGNALING.
APPLICATION FILED MAR. 26, 1920.

1,380,869.

Patented June 7, 1921.

2 SHEETS—SHEET 1.



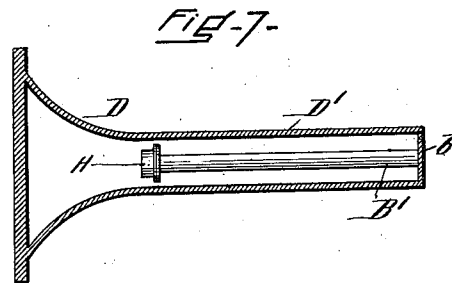
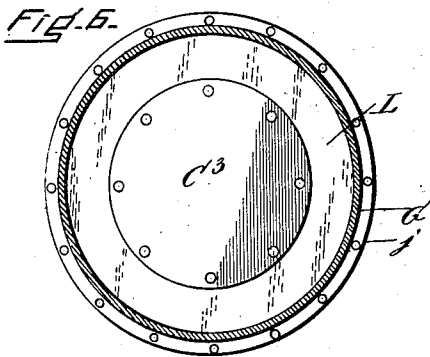
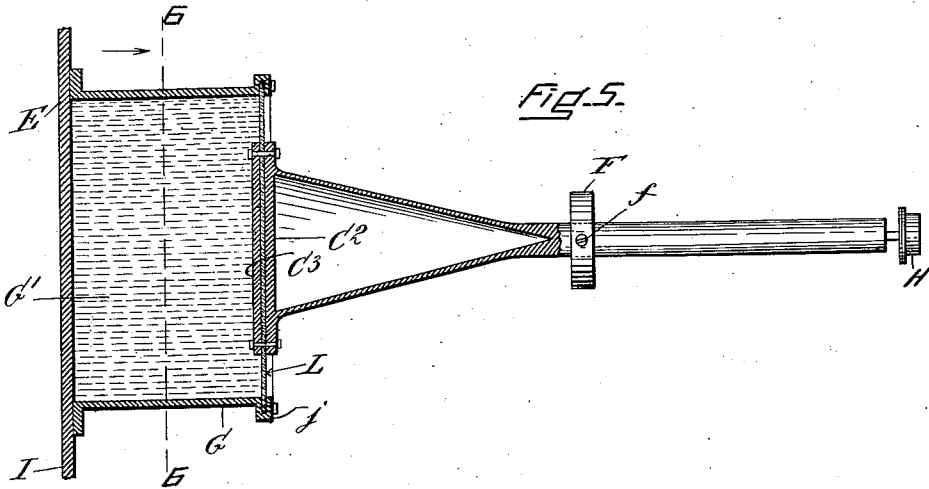
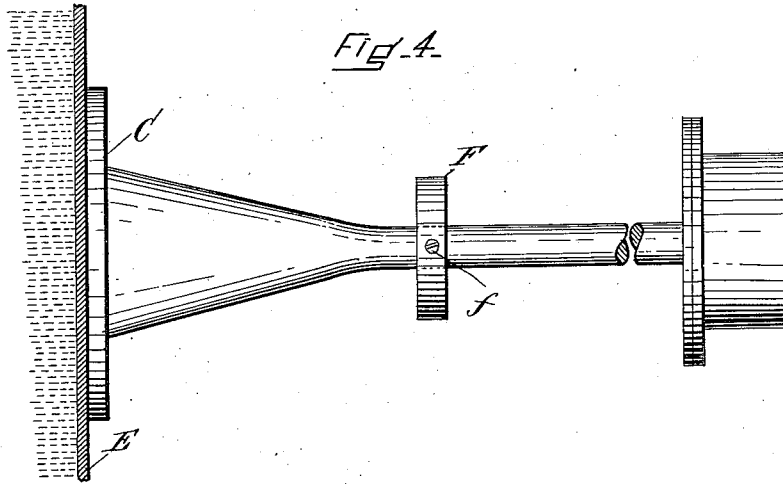
INVENTOR=
Richard D. Fay

By *Lowell Ottaway*
ATTORNEYS=

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2 SHEETS—SHEET 2.



INVENTOR=
Richard D. Fay
BY *Wm. H. Hays*
ATTORNEYS=

UNITED STATES PATENT OFFICE.

RICHARD D. FAY, OF NAHANT, MASSACHUSETTS, ASSIGNOR TO HAMMOND V. HAYES,
OF BOSTON, MASSACHUSETTS.

SUBMARINE SIGNALING.

1,380,869.

Specification of Letters Patent.

Patented June 7, 1921.

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To all whom it may concern:

Be it known that I, RICHARD D. FAY, of Nahant, in the county of Essex and State of Massachusetts, a citizen of the United States, have invented a new and useful Improvement in Submarine Signaling, of which the following is a specification.

In most devices heretofore employed for sending and receiving sounds in water or in air, diaphragms have been used having one surface in contact with the water or air, and it has been the motion of the center of such diaphragms that has been the most active agency in producing the desired effect. Diaphragms with fixed edges such as have heretofore been employed have certain inherent characteristics of which the two following need only be cited (a) diaphragms with clamped edges have proved very efficient both in sending and in receiving, but have their limitations owing to the natural frequency of the diaphragm itself and particularly to the nodal vibrations which are usually present and are often of an energy sufficient to interfere seriously with the propagation of the waves of a useful frequency; and (b) moreover, it is important that the amplitude of motion of a diaphragm or the like in the propagation of waves in water should not exceed a certain well defined limit, for, if this limit is passed, cavities are produced in the water which seriously reduce the amplitudes of the propagated waves.

A good transmitter or receiver of sounds must be so arranged;

(a) That practically all of the energy is used in transmitting sounds of the desired or necessary frequency; (b) That in an under water device the motion at the surface of discontinuity, *i. e.*, between the water and the sound-producing or receiving device, shall never exceed a definite extremely small amplitude;

(c) That at all points on the surface of discontinuity the movements will be as nearly as possible of like amplitude and phase; and,

(d) That the arrangement shall be such that the device will be equally effective as a producer or receiver of compressional waves.

I have accomplished the above-described results by the use of an arrangement in which an elastic rod of proper length and

diameter is employed. This rod is made to act upon a plate having a substantially plane surface which surface is in contact with the water or air and is so designed mechanically that it will not be distorted by the pressures exerted upon it when the device is used either for sending or receiving compressional waves such as those of sound.

By the use of my invention I am able to obtain results which so far as I know have never before been obtained and are, I am satisfied, essential to the best construction of underwater sound-sending and receiving devices, for when sending, I am enabled to utilize a source of vibrations requiring relatively large amplitudes for its efficient operation, reducing such vibrations, substantially without loss of energy, at the surface of discontinuity between the sound-sending device and the water; and, when receiving, to change the waves of small amplitude coming from the water into motion of larger amplitude at the point where mechanical vibrations are transformed into similar waves of electricity. Moreover, this may be accomplished by my invention in such a way as to insure to a remarkable degree the transmission of only the waves of the desired and necessary frequency.

In the practical construction of my device as a producer of sound waves in water, any convenient form of vibrator can be used. In embodying my invention I utilized a Fessenden oscillator (see U. S. Patent No. 1,167,366) so modified that the diaphragm of the oscillator served primarily as a means of supporting one end of the rod. The other end of the rod was expanded, for a small distance, into the form of a hollow cone in such a manner that the cross-sectional area of the metal portion of the cone was at all points equal to the cross-sectional area of the rod. The conical form given to the end of the rod is for the purpose of distributing the contact between the rod and the plane or substantially plane surface which is in contact with the water, and by so doing to assist mechanically in keeping that surface undistorted by the changing pressures exerted upon it. Any system which will distribute this contact will serve equally well provided the area of its cross section be kept constant.

In the Fessenden oscillator and in prac-

tically all sending and receiving devices there is a considerable amplitude of motion. On the other hand, the motion of the surface in contact with the water must be relatively small. It is this ratio of amplitudes at the two ends of the rod which is one of the important factors to be considered in the design of the mechanism.

To take the simplest form of my invention where the rod is of equal cross area throughout its length and one end is attached rigidly to a plate which is in contact with water or other medium and is of such rigidity as not to be distorted and with the resistance exerted when this plate is vibrated under working conditions, there are waves reflected from the plate back along the rod and each reflected wave will meet the advancing wave at some point along the rod. The rod should be of such length that the time required for the advancing wave to travel through it to this point shall be one quarter of the period of vibration of the transmitted wave. This is the shortest length of rod. If rods of longer lengths are to be used, the distance from the vibrating mechanism to the point of meeting of the pressure waves must be 3—5—7—, etc., quarter wave lengths. In other words, the main feature in this portion of the invention is the use of an elastic rod to connect the point of maximum vibration with that of minimum vibration of a length from the point of maximum vibration to the point of meeting of the direct and reflected pressure waves equal to an odd number of quarter wave lengths of sound of the desired frequency in the rod. If this principle is recognized it is not necessary to employ a rod of uniform cross section throughout its length, although the cross-sectional area of the metal in the cone and of that portion of the rod which extends from the cone to the point of meeting should be substantially equal. It is necessary only to design the rod so that the times of propagation of the direct and reflected waves are such as will produce a point of meeting of such waves at odd multiples of the quarter wave length from the end having maximum motion.

The cross-sectional area of the rod between the plate and point of meeting of the waves controls the ratio of the amplitude at the two ends of the rod. For ease in explanation the device will be considered as a sender. The difference of amplitudes at the point of meeting of pressure waves and at the generator is due to the length of rod between these points being such that the amplitudes of the generated and reflected waves will assist at the generator end and oppose at the point of meeting of pressures of the waves generated and reflected. Evidently the greater the amplitude of the reflected wave relative to that of the gener-

ated wave, the greater will be the ratio of the amplitudes at these two points. Hence, by giving the rod suitable cross section the amplitude of the reflected wave can be controlled and hence the amplitude ratio at these two points can be given any desired value. Clearly, with a rod of given size, the larger the area of the plate in contact with the water, or other liquid or gaseous medium, and the greater the weight of the plate acting on such medium, the greater will be the reflection. While in most cases it will be desired to have the reflected wave in phase with the generating wave at the end having maximum amplitude, it is possible to vary the phase of the reflected wave so that it will in effect add to or subtract from the weight of the moving parts of the vibrating device and hence change the frequency of the vibrations at which best efficiency is obtained. Such an arrangement is the simplest form in which the fundamental principle is utilized. It is clear, however, that a weight fastened to any part of the rod will cause additional reflections and I have found that the effect of the weight is equivalent to using a rod of different section or different length or both according to the magnitude of the weight and its position on the rod. Hence a weight or weights whose position on the rod may be varied furnishes a convenient means either for varying the frequency at which the desired ratio of amplitudes at the ends of the rod is obtained or for varying the ratio of amplitude at any frequency. In particular by the use of a weight a shorter rod may be made to give a desired amplitude ratio than would be possible if the weight were not used.

Furthermore, it is not necessary that the rod should have its full length between the vibrator, or microphone, and the plate. It is possible to obtain the same effect by using a rod inside of a pipe having the same area of cross section as the rod and having one end of the rod attached to one end of the pipe. In this case the free end of the pipe takes the place of the cone and is attached to the plate, the microphone or vibrator is fastened to the free end of the rod inside of the pipe and the combined rod and pipe are equivalent to a continuous rod of the same section and of their combined lengths.

Following out the above principles, I have found that when waves of a frequency of 540 a second are to be transmitted, a steel rod about 9 feet, 10 inches in length is required. Assuming a weight of plate of 150 lbs., and a diameter of one foot, an amplitude of $1/800$ of an inch at the surface in contact with the water and an amplitude of a little over $1/80$ of an inch at the oscillator, a rod $1\frac{1}{2}$ inches in diameter is effective.

tive. In the device which I have used the rod is expanded at its conical end to a diameter of 5 inches in a length of 10 inches, the cross-sectional area of the metal of the cone thus formed being equivalent to that of a solid rod $1\frac{1}{2}$ inches. Thus, in this particular device a rod of uniform cross-sectional area between the end of maximum movement and the plate in contact with the water is used.

In the drawings:—

Figure 1 is a side elevation partly in section of a device embodying the invention.

Fig. 2 is a similar view showing a different mounting of the contact plate, which is capable of being used in the air.

Fig. 3 is a side elevation of the device with microphone attached thereto.

Fig. 4 is a side elevation of a device embodying my invention with weight on the rod.

Fig. 5 is a similar view partly in section showing another way of mounting my device,

Fig. 6 being a section on line 6—6 of Fig. 5.

Fig. 7 is a view partly in section of a modification of my invention.

In Fig. 1 A is the mechanism used in transforming electrical oscillations into mechanical vibrations or transforming mechanical vibrations into electrical oscillations such as a Fessenden oscillator. B is a rod preferably made of steel so as to be elastic. One end of this rod is connected to the diaphragm of the oscillating device and forming part of the connection with a plate C. In the arrangement shown in Fig. 1 C is a plate attached to the skin E of a ship so rigidly that the skin of the ship will move with the plate C without any lost motion. The connection between plate C and rod B is made by the use of a hollow cone D which preferably is integral with the rod B and the cross-sectional area of the metal of which is equal to that of the rod. The thickness of plate C and the large diameter of the end of the cone D attached to it insure that all points in the surface in contact with the water, will when vibrated, move backward and forward with equal amplitude. When alternating currents of a definite frequency are passed through the oscillator, waves of compression are propagated along the rod and are partly reflected at the other end of the rod. The rod is given such length that the reflected wave will reach the oscillator in phase with its motion and thus tend to assist in increasing the amplitude of its movements. The more these waves are reflected the smaller will be the amplitude of motion at the water end of the rod and the greater will be the amplitude of motion at the oscillator end. When used as a receiving device the action will be the same. A

very small motion at the water end of the rod will operate to produce a larger amplitude of motion at the oscillator end of the rod and, consequently, induce great currents in the oscillator used as a generator of electrical currents.

In Fig. 2 a similar arrangement is shown, except that in this case the plate C¹ to which the rod B is attached by the cone D is in an opening in a partition or frame F which has a flange or packing G passing around the edges to the back of the piston. This form of the invention may be used for other signals than those sent from shipboard.

In Fig. 3 the same device is shown having a microphone button H attached to the end having maximum motion. By this arrangement the button is agitated more violently by a sound wave coming through the water than would be the case if the button were attached to the skin of the ship.

When a rod is used with a microphone, noises and vibrations which are carried by the skin of the ship may be reduced by having the plate form the back of a tank G of which the skin of the ship or other part E forms the front (see Figs. 5 and 6). The plate is insulated acoustically from the sides of the tank with rubber or similar material L. The tank which need not be completely inclosed is filled with water G¹.

In this case the plate may conveniently be made in two sections C², C³ which are clamped together by screws, the rubber insulating member being in the form of a disk and clamped between them. The edge of the part L is clamped against the end of the tank G by a ring j.

In Fig. 7 instead of a rod as shown in the other figures an equivalent therefor is shown, the cover D terminating in a tube D¹ to which is attached at its outer end by a plate b or other form of attachment a rod B¹ which lies within the tube and carries a microphone at its inner end. The combined length of the tube and the rod should be governed by the same rule as in the other forms of my invention.

While the rod and its cone is shown and described as being made in one piece, the invention is not limited to that construction, the invention relating rather to the provision of a continuous uninterrupted path of the general character described for vibrations from a vibrator to a substantially rigid plate such that the plate will be vibrated bodily by the vibrations conducted by the elastic rod and augmented because of the elasticity of the rod, and for this purpose the rod need not be integral nor need the cone engage the plate around its entire edge so long as the area of the cross section of the parts of the cone which engage the plate is substantially equal to the cross section of the rod adjacent to it as above described and that these parts

in engagement with the plate shall so contact with the plate as to cause it to vibrate as a whole without distortion.

In using the term "rod" I mean to include both a solid rod and a hollow rod or tube either of which, if properly proportioned as to length and metallic cross area, will provide such a continuous uninterrupted track for longitudinal vibrations as is required to secure the desired result.

What I claim as my invention is:—

1. A device of the kind described comprising two members and a rod connecting said members, said rod being made of elastic material whereby the motion of one of said members, when transmitted longitudinally through said rod to the other member, will have its amplitude changed.

2. A device of the kind described comprising two members, one member having a large freedom of movement and the other having a relatively small freedom of movement, and a rod connecting said members, said rod being made of elastic material whereby the motion of one of said members, when transmitted longitudinally through said rod to the other member, will have its amplitude changed.

3. A device of the kind described comprising two members and a rod of substantially uniform cross-sectional area connected rigidly to both of said members, said rod being made of elastic material whereby the motion of one of said members, when transmitted longitudinally through said rod to the other member, will have its amplitude changed.

4. A device of the kind described comprising two members, one member having a large freedom of movement and the other having a relatively small freedom of movement, and a rod connected rigidly to both of said members, said rod being made of

elastic material whereby the motion of one of said members, when transmitted through said rod, will set up movements of different amplitude in the other member, the end of said rod attached to the member having small freedom of movement being expanded, without change in cross area, whereby the rod will engage the member having small freedom of motion near its outer edge and the forces exerted at their points of engagement will include a large area.

5. A device of the kind described comprising two members, one having a large freedom of movement and the other having a relatively small freedom of movement, and an elastic rod connecting said members and adapted to transmit vibrations longitudinally from one member to the other, the length of said rod being such that at a point thereon approximating one quarter wave length from one member the wave reflected from the other member will meet a wave originating at the first member in opposite phase thereto.

6. A device of the kind described comprising a member having large freedom of movement, a member having small freedom of movement and an elastic rod connecting said members, the member having small freedom being adapted to reflect waves passing thereto through said rod, whereby the amplitudes of motion in different parts of the rod will be varied.

7. A device of the kind described comprising a member having large freedom of movement and a member having smaller freedom of movement and an elastic rod connecting said members and means whereby desired ratios of amplitude of motion of the two members may be obtained at various periods of vibration by means of the longitudinal vibration of said rod.

RICHARD D. FAY.